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Radioactive Fallout—How large is a small risk?

"Our generation has succeeded in stealing the fire of the gods, and is doomed to live with the horror of its achievement," writes Henry A. Kissinger in a book, *Nuclear Weapons and Foreign Policy* (New York, Harper and Brothers, 1957. $5.00). The book is concerned with the implications of nuclear explosives for military strategy and the conduct of foreign policy and international relations generally. It was written after three years of discussion with a group of informed persons convened by the Council on Foreign Relations, New York. The main discussion, so far as United States policy is concerned, is over a variety of nuclear weapons needed for the purpose of deterring the varied threats that come from time to time from the Soviet Union.

In this issue of INFORMATION SERVICE reference is made to portions of the current public controversy concerning the health of the people while the weapons are being developed. In this discussion, scientists, government officials, and churchmen, among others, are taking part.

"Clean Bomb"?

The extensive public debate, sometimes called an "outcry," has recently been influenced by the announcement, June 24, 1957, at the White House, that three prominent atomic scientists had informed the President that the radioactive fallout from testing bombs, the subject of much writing and speaking, had already been greatly reduced, and that further refinements of technique would in about five years result in making the fallout "essentially negligible." The scientists also gave the opinion that it would be possible to produce a "small" hydrogen bomb. A small hydrogen bomb might become a useful "tactical" weapon because it could be used against military targets without fear that its devastating effects would kill or injure many persons at a considerable distance from the target. The small clean hydrogen bomb would also be of first importance because its use would permit ground troops to follow through or to approach without fear of radioactive contamination of debris near the point of destruction.

The report to the President by the three atomic scientists was arranged by the Joint Committee on Atomic Energy of Congress, whose members had previously heard the scientists testify. Those reporting were physicists at the University of California: Ernest O. Lawrence, director of the Radiation Laboratory; Edward Tiller, associate director; and Mark M. Mills, head of the theoretical division of the laboratory. Dr. Lawrence was quoted in *The New York Times,* June 25, as stating: "We are convinced" that it is possible "to produce nuclear weapons that are in a sense just like TNT, except tremendously more powerful. They are an explosive—the fallout radioactivity is a small element in the picture with such weapons."

In a review of the matter, William L. Lawrence, science editor for *The New York Times*, in that newspaper, June 30, 1957, noted that President Eisenhower had stated at his press conference the previous week that the scientists are now producing bombs that have 96 per cent less fallout than was the case with the original bombs which are now called "dirty." The President was also reported to have stated that scientists had told him that if given four or five years more for testing every step of the development "an absolutely clean bomb" could be produced.

Mr. Lawrence writes that "both statements need a certain amount of elucidation." He thinks if 96 per cent of the fallout has been eliminated, then the process of manufacture has been changed. The original dirty bombs were produced by the fission of two isotopes of uranium, but now apparently 96 percent of the explosive power comes from the fusion of the heavy varities of hydrogen, a process that does not produce a fallout. Thus a "small" bomb, only as destructive as those used over Japan, would produce only a relatively small amount of fallout products. But the monster of the type tested in the Pacific in 1954, producing an explosive force reported to be equal to 15,000,000 tons of TNT, would produce fallout thirty times that of the type used in Japan. It is assumed, writes Mr. Lawrence, that the monsters need no longer be tested, and that the emphasis now is on the production of the smaller hydrogen bombs. It is the elements used to "trigger" the hydrogen bomb that produce the fallout. The announcement must mean, writes Mr. Lawrence, that the scientists are of the opinion that the fallout from the "refined weapons would be so small that it would be . . . insignificant for all practical purposes."

"Clean Bombs and Dirty Wars"

The announcement has had a varied response. One has been the observation that even if fallout could be practically eliminated, the devastation at the target point would still be horrible, and that an explosive weapon which could produce millions of corpses and practically destroy our cities should not be called "clean."

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One of the most vigorous comments came from Norman Cousins, editor of *The Saturday Review*, New York, in that weekly journal, July 13, 1957. The first paragraph in the editorial reads:

"Almost without realizing it, we are adopting the language of madmen. We talk of 'clean' hydrogen bombs, as though we are dealing with the ultimate in moral refinement. We use fairyland words to describe a mechanism that in a split second can incinerate millions of human beings—not dummies or imitations but real people, exactly the kind that you see around your dinner table. What kind of monstrous imagination is it that can connect the word 'clean' to a device that will put the match to man's cities? Yes; what is really meant by 'clean' is that we may be able to build a bomb with a greatly reduced potential for causing radioactive fallout. But to call a hydrogen bomb or any bomb 'clean' is to make an obscene farce out of words."

Further: "It is made to sound as though something beautiful and gleamingly wholesome were coming into a man's life. We seem to forget that this is human tissue that is involved here. Also human germplasm. And the effect on both of added radiation is a cheapening and a damaging effect, and therefore an evil one. To use the pretty words of the nursery in connection with such an effect is to engage in a fiendish act of moral shrinkage."

"There was," writes Mr. Cousins, "a general air of jubilation about the announcement, as though this was the deliverance the human race was waiting for. The announcement [at the White House] said nothing about the fact that what the world is waiting for is not a better way to make a 'clean' hydrogen explosive, but a better way to get rid of dirty wars."

Do those who are jubilant think that the nuclear armaments' race will be called off? "Do they think unlimited freedom to continue unlimited testing will cause the present world anarchy to disappear?"

A laboratory is not the whole world, even though a laboratory may be very important to the scientists of the Atomic Energy Commission. "The whole world is a world of movement . . . And it is precisely the boiling and churning of the unpredictables that make it necessary today to bring the weapons of mass destruction under control, to define new relationships among the nations, and to make these new relationships work under enforceable law."

Albert Schweitzer's Appeal

On April 24, 1957, the Nobel Prize Committee, Oslo, Norway, issued Albert Schweitzer's "Appeal to Conscience," prepared by the noted physician and missionary at Lambarene. He had been urged by the Committee, by prominent scientists in Europe, and others, including Norman Cousins who earlier went to Lambarene, to issue the statement. He had at first declined, partly because of a lifelong practice of not issuing or signing pronouncements. He told Mr. Cousins that he had always felt his contribution to the world should come out of his attention to music, theology, philosophy, and medicine. But Dr. Schweitzer finally decided to prepare a declaration and hand it to the Nobel Committee. Radio Oslo broadcast the full text, as apparently did radio stations in many other nations in the world. A check made by *The Saturday Review* indicated that three nations in which the appeal was not broadcast *in full* were the United States, the Soviet Union, and Communist China. The appeal was published in full in *The Saturday Review*, May 18, 1957.

"We are committing a folly in thoughtlessness . . . We must muster the insight, the seriousness and the courage to leave folly and to face reality." Dr. Schweitzer concluded that the main reason why there was no agreement to stop the testing of nuclear weapons was because public opinion was not being effectively expressed.

For many years the world was not aware of the danger of radiation to those operating X-ray apparatus. As a result thousands of physicians and nurses were injured. The results of radioactive fallout from testing of hydrogen weapons have now been studied and analyzed. Good evidence has accumulated. While the materials collected are not complete, it enabled Dr. Schweitzer "to draw the conclusion that radiation resulting from the explosions which have already taken place represents a danger to the human race—a danger not to be underrated—and that further explosions of atomic bombs will increase the danger to an alarming extent." Dr. Schweitzer notes that many others have expressed the same conclusion.

The testing of an atom bomb "creates an inconceivably large number of exceedingly small particles of radioactive elements which decay like uranium or radium." Certain of these particles decay "extraordinarily slowly." Although the amount of radioactive elements in the air, and even the water, may be very small, it also affects vegetation and soil. "Unfortunately, for us, nature hoards what is falling down from the air." Thus "none of the radioactivity of the air" is unimportant.

On one occasion, Dr. Schweitzer notes that the radioactivity of the water in the Columbia River, into which the Hanford atomic plant deposits waste matter, was "insignificant." But the radioactivity of the plankton found in the river was 2,000 times higher than that of the water; that of ducks eating plankton, 40,000 times higher; that of fish, 150,000 times higher.

"The cells of the red bone marrow, where the red and the white blood corpuscles are formed, are very sensitive to radioactive rays. . . .

"Not our own health only is threatened by internal radiation, but also that of our descendants." Among the descendants of 3,000 operators of X-ray apparatus a higher percentage of stillbirths has been found than among non-radiologists.

"We are forced to regard every increase in the existing danger through further creation of radioactive elements by atom bomb explosions as a catastrophe for the human race, a catastrophe that must be prevented."

Scientists vs. Scientists

In the public discussion preceding and following the Schweitzer appeal, scientists have been arrayed against scientists, so much so that many a lay reader may have been tempted to give up in frustration. But in an article, "Fallout and Health," in *The New Leader*, New York, July 1, 1957, Walter C. Bauer, a physician, and John M. Fowler, a professor of physics, suggest that "it is not the scientist, neither AEC [Atomic Energy Commsision] employee nor university professor, who must decide this question. The decision must be made by an informed and concerned public."

"The risk is extremely small," wrote Willard F. Libby, a member of the Atomic Energy Commission of the United States, in "An Open Letter to Dr. Schweitzer," April 25, 1957. Dr. Libby was formerly of the Institute for Nuclear Studies, the University of Chicago. Dr. Libby's letter was widely published and appeared in full in *The Saturday Review*, New York, May 25, 1957, as part of a forum on the Schweitzer declaration.

Dr. Libby doubts that Dr. Schweitzer has had "access to the most recent information." The Government of the United States does take account of the possible hazards.

There are "some differences in findings of scientists," but there is general agreement "upon the approximate magnitude of the fallout and the rate at which it is descending . . ." "There is less agreement about the magnitude of the physiological effects which can be expected to result from fallout radiation." The U. S. Government is endeavoring to have "very small test radiation" and is endeavoring to reduce it.

"I do not mean to say that there is no risk at all. What I would like to demonstrate to you is that the risk is extremely small compared with other risks which persons everywhere take as a normal part of their lives. At the same time, I ask you to weigh this risk against what I believe would be the far greater risk—to freedom-loving people everywhere in the world—of not maintaining our defenses against the totalitarian forces at large in the world until such time as safeguarded disarmament may be achieved. Of course, a workable, safeguarded system of international disarmament is a paramount objective of the United States Government, and one which we must work for and hope and pray will be achieved. . . ."

"What is a 'small' risk?" asks Harrison Brown in a "counter-reply" to Dr. Libby, appearing in the same issue of the *Review*. Dr. Brown is professor of geochemistry at the California Institute of Technology and has been associated with the plutonium laboratory at Oak Ridge, Tenn. "Continued testing at the present rate may well result in the death each year from leukemia of nearly 10,000 persons who would not otherwise have died." Dr. Brown refers to the concern of geneticists, and particularly to findings of E. B. Lewis of the California Institute of Technology "who found that the incidence of leukemia is increased with exposure to low-dosage radiation." And, Dr. Brown goes on: "Leukemia is but a single manifestation of danger caused by low-dosage radiation. Are there others? We don't know, but it would be surprising if there were not. And if there are, it seems unlikely that the AEC will discover them if they continue to operate within the framework of their present philosophy."

We print below the major portion of a background paper recently presented to the Commission of the Churches on International Affairs by Alan Booth and Richard M. Fagley of the staff of the Commission, because it is a careful summary of much of the current output by scientists on the health aspects of the radioactive fallout.

"Clouds from Nevada"

This is the title of a "special report" by Paul Jacobs in *The Reporter*, New York, May 16, 1957, on the Atomic Energy Commission's "Weapons-Testing Program."

"A blinding flash, a great bang, and a shaking of the earth . . . are no longer novel sounds and sights to the people living in Nevada and Utah near the test site," which is located 90 miles northwest of Las Vegas, Nevada. Most people in the area go about their usual ways when a weapon is tested, but others, "justifiably or not, . . . regard the Atomic Energy Commission as an army of occupation" and are "filled with apprehension and dread."

In 1956, Martin Bardoli, aged 7, living on the Fallini Ranch, near Warm Springs, Nev., some 100 miles from the test site, died of leukemia. One of the doctors attending him said his disease "may have resulted from the atomic explosions in southern Nevada." Actually, writes Mr. Jacobs, although the Atomic Energy Commission maintains that leukemia may be brought on only by much larger doses of radiation than Martin Bardoli received, the AEC "does not know how much radiation exposure 'Butch' Bardoli received as a result of radioactive fallout from its weapon-testing programs."

Complaints come from people who have contracted cancer; from sheepmen and cattlemen whose animals have died. But the AEC's official attitude seems to be "keep smiling." Two ranchers, Dell and Cornell Stewart, reported in June, 1953, that 16 horses had been burned and "six cattle had dropped dead" after leaving a water-hole at Papoose Lake and claimed that the water had been "badly affected by radioactive fallout." The Government indemnified the ranchers for the horses, but not for the cattle. It apparently pays for burns that can be seen and has the policy "to deny everything else."

"Public relations was apparently at least as important as public health" to the AEC official who wrote that "to deny the owners the use of waterholes would bring about new problems to both owners and the Government. . . The waterholes were not closed."

The AEC's public relations has also been accompanied with considerable public pressure. Whenever Robert Crandall, editor of the weekly *Times-Bonanza* of Tonopah, Nev., publishes material that the AEC regards as "critical," the AEC's public relations men call on him to make "corrections." The AEC, e.g., was quick to ask for "corrections" of publications of statements made by Linus Pauling, a chemist of the California Institute of Technology, on the genetic effects of exposure to radiation. Mr. Jacobs writes that in the area "information is hard to get."

The AEC also used its influence to prevent Herman J. Muller, of the University of Indiana, a distinguished geneticist and Nobel Prize winner, from delivering a paper on the genetic damage of radiation and fallout, at the International Conference on the Peaceful Uses of Atomic Energy in Geneva in August, 1955. The paper had previously been accepted by the technical staff of the United States delegation.

The AEC, thinks Mr. Jacobs, pays more attention to testing weapons than to investigating the hazards to health of radioactivity. It imposes a high degree of conformity on its own scientists. Mr. Jacobs concludes that the guarding of public health should be separated from development of weapons, as has been done in Great Britain. There, the Medical Research Council, with 1,000 employes, is independent of the Atomic Energy Authority. The Medical Council there "has full liberty to appoint its own research officers and to pursue its own scientific policy."

Choosing Among Risks

Expressions of concern from church bodies throughout the world have been numerous. The World Council of Churches, Geneva, issued, May 14, 1957, in mimeographed form a selection, "Statements on Nuclear Weapons," made during the past few years. Pope Pius gave a message to the Japanese envoy, Matsushita, April 14, 1957, noting "the exhausting and costly race toward death," and stating that "scientists of all nations and all faiths must feel grave moral obligation to pursue the noble aim of harnessing these energies for the service of man."

O. Frederick Nolde, director of the Commission of the Churches on International Affairs of the World Council of Churches and the International Missionary Council, discussed the experimental nuclear tests, and summed up the current dilemma of the free world as follows in an address, May, 1957, before the U. S. Conference for the World Council of Churches:

"The Problem. While there is common agreement that radioactive fallout from nuclear weapon explosions can adversely affect health, there are disagreements and un-

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certainties as to whether the danger exists at the present level of experimental tests or whether the potential danger will become real only if tests are continued and accelerated. Two kinds of risks are involved. The first is the danger to health and in this connection the hazards attached to peaceful uses of atomic energy must not be overlooked. The second is the risk in negotiating such international agreements to discontinue tests that will at the present time clearly be inadequate because, in dealing with only one segment of the disarmament problem, they will not equivalently ensure the security of all countries. The problem reduces itself to the difficult choice between an apparently uncertain risk to health and an apparently clear risk to security.

"*Proposed Action.* There should be a firm commitment to discontinue experimental tests of larger nuclear weapons either at the time when the danger to health is established with reasonable scientific certainty, or at the time when an adequate international agreement can be negotiated. Information should be continuingly solicited from scientists, particularly from those who are brought together under impartial, international auspices. If at any time scientific opinion preponderantly asserts an immediate risk to health, the risk of an inadequate international agreement to discontinue tests must be run."

The Violent Force of the Bombs

The Effects of Nuclear Weapons is the title of a 579 page handbook compiled by the Department of Defense, published by the Atomic Energy Commission, and sold by the Superintendent of Documents, Government Printing Office, Washington 25, D. C. (1957. $2.00). It brings down to date the information in a previous volume issued in 1950.

The Problem of Waste Disposal

A recent incident in the disposal of radioactive waste from an industrial plant highlighted a problem which may become more and more difficult. Steel drums were being transported to sea, to be sunk 185 miles southeast of New York. The fuse of one drum failed to function, and instead of sinking began to drift on the surface of the ocean. The drum was filled with radioactive sodium and according to reports might have caused damage from explosion if it had been struck by a ship. After frantic efforts the Coast Guard located the drum, and it was sunk by gunfire from airplanes on July 16, 1957.

This is but one of the problems dealt with in an article, "Is Atomic Power Safe?" by Charles M. Herzfeld, a physicist, in *The Commonweal,* New York, May 31, 1957. "Here one will have to deal with a steady accumulation of tons of highly radioactive materials. These cannot be stored among populations indefinitely . . . A promising disposal scheme is that of forming the wastes into brick-like chunks which would be dumped into the deep valleys of the ocean floor. To prove this scheme feasible, the rate at which water from these deep valleys mixes with the rest of the ocean must be determined. . . . Research in geophysics is required and must be carried out on an international scale, another example of the urgent need for international cooperation in atomic matters."

Laymen's Summary of Scientific Opinion

Following is the main text of a paper, "Notes on the Health Dangers of Radioactive Fallout," prepared by Richard Fagley and Alan Booth of the staff of the Commission of the Churches on International Affairs. The paper was presented to the Commission in July 1957:

Notes on the Health Dangers of Radioactive Fallout

To facilitate discussion of the complex of problems surrounding the development of atomic power in a divided world, we have tried to summarize some of the concerns and conclusions of scientists regarding the hazards to health from bomb-test fallout of the delayed or general type. On this aspect . . . , which has been clouded by public controversy, we have sought the advice of scientists on both sides of the Atlantic and have tried to take into account the major studies now available. The summary which follows is our attempt, as laymen in this field, to report what seems to us the main burden of responsible scientific opinion. The value of a compilation of this sort is clearly very limited, and the chief justification for duplicating it is that a brief up-to-date digest on the subject is not at hand.

The main documents referred to here are *The Biological Effects of Atomic Radiation,* (June 1956), the summary reports of a study sponsored by the (U.S.) National Academy of Sciences (NAS); *The Hazards to Man of Nuclear and Allied Radiations,* (June, 1956), the report of a committee appointed by the Medical Research Council in the U. K. (MRC); and *Effect of Radiation on Human Heredity,* the report of a World Health Organization study group soon to be published. This latter study dealt more with the need for research than with the present dangers, but noted that the study group was in "essential agreement" with the findings and recommendations of the NAS and MRC studies. The desirability of more widely representative findings is clear, but the report of the United Nations Scientific Committee on the Effects of Radiation is not expected for another year.

While the ensuing notes focus on the dangers from bomb-test fallout, it seems to us clear that these hazards should not be abstracted from the far greater perils involved in the insecurity of this atomic age. In terms of radiation alone, an atomic war would multiply a thousand fold the present dangers from fallout. The risks which stem from bomb testing must be weighed against the various risks inherent in policy in the field of international security. Reflecting this point of view, we have added a few questions on these wider considerations to the notes on the genetic and non-genetic dangers of test fallout.

1. *The Genetic Danger*

The genetic danger from atomic radiation is real even though it is not now possible to describe in precise and meaningful terms the injury to future generations. The gravity of the danger stems from the fact that an injury of uncertain dimensions is being wrought upon the genetic heritage of the human race. The geneticists generally agree that any increase in radiation increases the danger to some degree. While knowledge of the effects of small doses is still scanty, the WHO study group concluded that "there are strong grounds for believing that most genetic effects are very closely additive so that a small amount of radiation received by each of a large number of individuals can do an appreciable amount of damage to the population as a whole."

While the mutation of genes is essential for evolution, the overwhelming majority of mutants are injurious. Consequently, geneticists regard any increase in the mutation rate for man as being clearly harmful. This harm is not immediately or fully evident because the majority of mutant genes are recessive. Also, many result in embryonic deaths, and the majority produce defects of a minor character. On the other hand, those that do not result in

death or sterility tend to persist from generation to generation and are cumulatively serious.

Spontaneous or natural mutation is caused in part by external factors: by background radiation from the earth and sky, by heat, and by chemical agents. The effect of the two latter factors must be considerable. The British and American studies now put the average background radiation dose to the gonads during the reproductive period at three roentgens. (A calculation for Sweden was 2 to 5 r.) To double the mutation rate by radiation alone, according to the NAS study, would require a dose of from 30 to 80 r. ("Almost surely more than 5 r and less than 150 r. It may very well be from 30 r to 80 r.") Thus, only part of the defects due to spontaneous mutation are the result of background radiation.

Moreover, the radiation from bomb test fallout to date is small in relation to background radiation. Taking 30 years as the reproductive period, and assuming a continuation of bomb tests at the rate of the past few years, the NAS report estimates the cumulative dose to the gonads in the U. S. at 0.1 r, with a range of uncertainty from 0.02 r to 0.5 r. The MRC report put the figure for Great Britain at 0.026. Thus, if tests continue but do not increase, fallout radiation affecting reproduction may be equivalent to from $\frac{1}{10}$th to $\frac{1}{100}$ of that from the natural background, with a corresponding increase in genetic mutation. Since the dosage from cosmic rays varies with altitude (in some places in the U. S. at a higher elevation the background rises to 5.5 r) moving to a place say 500 to 1,000 ft. higher above sea level may have more genetic significance for the persons involved than test fallout. People living near radioactive minerals may receive a hundred times as much radiation from that source as from fallout. But the fallout is in addition to background radiation, and affects all mankind.

In the more developed countries, the dosage from fallout is small in comparison with other forms of "man-made" radiation. The chief of these is X-rays used for diagnostic and therapeutic purposes. The British report estimated the dosage from X-rays for diagnostic purposes at 22% of the background, in the U. K. (and all such radiations at 25 per cent, or less than 1 r). The NAS group estimate total radiation of the gonads by X-rays, for the U. S., to be in the neighborhood or 3 r to 5 r, with a considerable range of uncertainty, but probably 10 to 100 times as much as fallout radiation. Thus, without special precautions, 20 dental X-rays may be equivalent in genetic effect to 30 years of test fallout, and one fluoroscopic examination may be 20 times as large.

There are also minor sources of radiation. The British report calculates the 30-year dose to the gonads from a luminous-dial wristwatch at 0.3 r, or more than that from 30 years of fallout at the rate of testing in recent years.

Such comparisons are frequently used to show the relatively small genetic danger which bomb testing to date presents. Many geneticists, however, in the light of the new studies of radiation and genetic mutation, would turn this around to underscore the relatively large danger presented by the radiation used for comparison purposes. The fallout question has directed new attention to the need for curbing any unnecessary radiation. The NAS report suggested, tentatively and subject to review, that a reproductive dosage of 10 r, in addition to the natural background, be regarded as the reasonable (not safe) upper limit for the population as a whole. (A higher limit of 50 r during the reproductive period, was proposed for those in occupations involving special exposure.) As the NAS report concluded: "We must watch and guard all our expenditures (of radiation). From the point of view of genetics, they are all bad." The First International Congress of Human Genetics stated:

"The damage produced by ionizing radiation on the hereditary material is real and should be taken seriously into consideration in both the peaceful and military uses of nuclear energy as well as in all medical, commercial and industrial practices in which X-rays or other ionizing radiation is emitted. It is recommended that the investigation of the amount and type of damage and of related genetic questions be greatly extended and intensified with a view to safeguarding the well-being of future generations."

In sum, the geneticists in general tell us that no amount of radiation is too small to be damaging to the genes. While "our knowledge of the effects of small doses over long periods is very scanty" (Prof. R. M. Sievert, Sweden, in the WHO report), the weight of scientific opinion is against the idea of a threshold, which must be exceeded before genetic damage is done. There is a "threshold" of another sort, however, which must be taken into the calculation of risks. The NAS report refers "to the possibility that increased and prolonged radiation might so raise the death rate and so lower the birth rate that the population, considered as a whole, would decline and eventually perish. We are at present extremely uncertain as to the level of this fatal threshold for a human population. This is one reason why we must be cautious about increasing the total amount of radiation to which the entire population is exposed."

The risks of bomb testing, not to mention atomic war, are therefore real from a genetic point of view, even though it is hard to translate the damage to future generations into concrete terms. Definite figures (such as the calculation by Dr. Warren Weaver that fallout may increase the estimated 30 million genetically handicapped babies among the next 15 billion to be born by perhaps 6,000), indicate the nature of the concern, rather than reflect precise knowledge. Indeed, it is the uncertainty as to the amount of genetic damage that constitutes a major part of the hazard.

2. Pathological dangers

The effects on individuals of large doses of radiation, such as might occur in the vicinity of a bomb test or in the event of nuclear war, are outside the scope of this paper. The present concern is to summarize the estimates of possible damage to individuals from a relatively small increase in radiation to which mankind may be exposed as a result of atomic experiments and activities. The main pathological dangers in this connection appear to be two: an increase in the incidence of leukemia from external radiation, and of bone cancer from the absorption of radioactive materials.

External Radiation—Leukemia. There is a general agreement that whole-body radiation on a substantial scale can induce leukemia in man, and has done so in some cases where therapeutic radiation has been used and also among survivors in Hiroshima and Nagasaki. British scientists recently are coming to believe that this condition increases in curvilinear proportion to the size of the radiation dose; it certainly begins to mount steeply only after smaller doses are exceeded, but suggestive correspondence of dose and incidence is established. Since little is known about the possible relationship between the the incidence of leukemia and chronic low-level exposure, the significance of bomb test fallout in this respect is

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uncertain. On the whole, the warnings on this pathological risk do not compare in urgency with those on the genetic peril. The MRC report, while recommending that the level of exposure to external radiation be kept as low as possible, thought an individual could accept, without undue concern about leukemia, a life-time dose of 200 r (in addition to natural background radiation), provided the maximum weekly exposure does not exceed 0.3 r. This latter figure is roughly comparable with the life-time exposure from test fallout at the rate of recent years. The NAS report expresses the view that, while the permissible exposures for individuals may be dangerous for large populations, the level permissible from the genetic point of view (10 r over the reproductive period) would have "no demonstrable somatic effect."

On the other hand, the link between radiation and leukemia, the scanty knowledge of the effect of chronic exposure to small doses, and the rise in the incidence of leukemia (e.g., from 11 per million to 49 per million annually between 1920 and 1954, in England and Wales—only partly explained by better diagnosis), all suggest that fallout involves some pathological risk. One expert has calculated that, on the most pessimistic assumptions, bomb testing would produce an increase of less than 2 per cent in the incidence of leukemia. When this small percentage, however, is applied to a world population approaching 3 billion, it becomes clear that the fate of a considerable number of people is at stake—perhaps an additional 1,000 victims each year.

Of the delayed action consequences of increased whole-body radiation, leukemia is the condition about which most is known. There is the possibility that other forms of anemia, cataracts, skin and lung cancer, and a shortening of the life-span from non-specific damage may also result, but the minimal dosage required for these is not known.

Internal Radiation—Bone Cancer. This becomes important in so far as radioactive fallout may be ultimately ingested by human beings and settles in the body. The element most significant here is the isotope strontium 90, because a good deal is produced by nuclear fission; it is widely dispersed and is deposited gradually, it is radioactive for a long time, with a half-life of 28 years; and it is chemically similar to calcium and can enter as a substitute the food chain of plant and animal life. The tendency is for this substance to become lodged in bone, and in due course under certain conditions to produce a breakdown in blood-forming tissues and cancer of the bone.

Because of inadequate knowledge about radiostrontium, there is considerable diversity among scientists as to how large a contamination danger it presents. It is the subject of very active research, which may in time establish the basis for a more significant consensus. On the whole, the tendency of scientists is to take a graver view of the possible perils from strontium 90 than was formerly the case.

It is true that the amount thus far found in human bones is small, 1 to 2 micromicrocuries in young children (England), and less in adults. The maximum permissible amount for the population as a whole is stated as 100 m.m.c., a figure derived from the maximum of 1,000 m.m.c. set for adults in special occupations by the International Commission on Radiological Protection. Also, the internal radiation produced by this radiostrontium is small compared with that produced by natural radioactivity. The director of the Health and Safety Laboratory of the U. S. Atomic Energy Commission estimated that the maximum dose from strontium 90 absorbed from the fallout produced by past bomb tests (Nov. 1956) would range from 7 to 30 per cent of the dose delivered in the U. S. by natural radioactivity.

It should be noted, however, that this internal radiation is in addition to that produced by other causes. Also, it does not take into account the strontium 90 released by continuing tests. Dr. Willard Libby of the A. E. C. states that continued testing at the present rate might lift, in a few decades, the concentration of radiostrontium in human bones to 5 to 20 per cent of the maximum permissible limit.

Moreover, the danger is far greater in areas deficient in calcium. In such areas the ingestion of strontium 90 occurs at a markedly higher rate at least for grazing animals. In certain parts of Wales, for example, sheep have been found with 150 m.m.c. of strontium 90 in their bones. While human beings, with a more varied diet, face a less immediate peril, Dr. Libby indicates that people in calcium-deficient areas might have 5 times as much radiostrontium in their bones as the population in general. Such people, given the continuance of testing at the present rate, might reach the permissible maximum after some decades.

It should be remembered, furthermore, that knowledge of the biological effects of radioactive strontium is too limited to regard the "permissible maximum" of 100 m.m.c. as an established standard. It is thought to be a reasonable level, because the internal radiation caused by such an amount would be roughly equivalent to that produced by natural causes, and because known damage has been reported only after far larger doses have been accumulated. But studies of the effects of smaller doses may conceivably lead to a downward revision of the present standard.

While the pathological perils of fallout may not be commensurate with the genetic danger affecting the future of the race, they nevertheless cannot be wholly dismissed as unreal. Mankind has moved into the atomic age with very inadequate knowledge of the consequences of this newly-acquired power. It may be that the hazards to the health of this and future generations from radioactive fallout will prove to be small. It may very well be that the risks will prove tolerable when weighed against risks of a different order which could flow from a unilateral or unreliable cessation of bomb testing. But the hazards to health, whether they stem from actual danger or ignorance of the facts, must not be ignored. They must be reckoned with fully in any moral calculation of policy.

3. *Weighing the Risks*

Since, as indicated at the outset, the prevention of atomic war must be the main consideration, even from the point of view of the threat to health from delayed fallout, it is clear that the demand to stop the bomb tests which continue to produce fallout must be judged in relation to this over-riding concern. If the scientists agreed that grave damage was being done to the present or future generations by test fallout, the case would be different, and stopping the tests would become a predominant moral imperative. The situation is not that clear. There is damage of uncertain extent to the genetic heritage and there is possible pathological damage. But knowledge to date does not establish that the actual and possible damage are of compelling gravity, even though they may spell suffering or death for many people. Consequently,

the risks to health from test fallout must be weighed against risks of a different sort.

Without attempting any analysis of the arguments for continuing the testing of atomic weapons or for stopping such tests only under certain conditions, we indicate a few of the issues which need to be taken into account.

1. *How essential is continued bomb testing to the maintenance of a relatively effective deterrent against resort to atomic war? . . .*

2. *How important is testing for the development of smaller or more precise atomic weapons? . . .*

3. *How important is testing for the development of relatively "clean" atomic weapons? . . .*

4. *Is there danger in treating as a separate issue the question of an agreement to halt testing rather than as an integral part of a disarmament agreement? . . .*

C.C.I.A. on Atomic Tests and Disarmament

Following is the full text of a statement on atomic tests and disarmament adopted in July, 1957, by the Commission of the Churches on International Affairs, of the World Council of Churches and the International Missionary Council, and commended by the Central Committee of the World Council, August 5, "to the attention of the member churches":

"The peoples of the world have been visited by a new fear. They are moved, indeed deeply alarmed, by current tests of nuclear weapons. These to them appear to be a portent or shadow of world conflict. At the very least, these tests seem to them to carry a potential and grave menace to health.

"The hazards to health from nuclear experiments must be taken seriously. All people are affected in some degree by radioactive fallout. More important is the effect upon generations yet unborn. The degree of damage may thus far be comparatively small, but uncertainty itself gives rise to genuine anxiety. But fear alone is no sufficient basis for the pursuit of moral ends.

"We must point out that this world-wide concern in which we share has deeper roots. Tests are taken to be a visible sign of preparations for atomic warfare. Vast areas could be depopulated by the powers of destruction now available and the dangers of fallout be multiplied a thousandfold. The main concern must always be the prevention of war itself, for the evil of war is an offense to the spiritual nature of man. But since any war carries increasing danger of becoming an atomic war, this task makes the prevention of atomic war, which shocks the conscience of mankind with a peculiar repugnance, all the more imperative.

"The total problem involved is so baffling and complex that no man can speak with certainty. All must humbly confront the issues, for all are involved. The mounting stockpiles of atomic weapons and increasing dependence upon atomic deterrents heighten the danger that atomic weapons will at some point actually be used. Yet, in the judgment of many, our present insecure peace rests mainly upon the possession of atomic deterrents on both sides of a divided world and upon the suicidal character of atomic war. This paradox does not relieve us of the need to examine our goals and the means thereto.

"I. *What Is Needed?*

"The objectives of a strategy to overcome the menace of atomic war are interrelated and interdependent. And they must be pursued in such a way as to safeguard as fully as possible the security of all nations. While they may be variously stated, we urge consideration particularly of the following:

"(a) To stop, by international agreement, the testing of nuclear weapons; and

"(b) To bring to a halt the production of nuclear weapons, under such controls as will most fully ensure compliance; and

"(c) To develop measures which will reduce national armaments, nuclear and conventional, with provision for necessary safeguards as such measures are progressively taken; and

"(d) To accelerate international cooperation in the development of atomic power for peaceful purposes, under proper safeguards; and

"(e) To establish more effective mechanisms for peaceful settlement of international disputes and for peaceful change.

"Together, these objectives form a framework for responsible action against the atomic threat as a whole. Each is important in itself, but more important in combination with the others. In this connection, we note the following:

"(a) *Atomic Tests.* It is important that compliance with agreements to stop testing nuclear weapons be verified internationally. Otherwise, distrust may in fact be increased. Further, such agreement should be related to general disarmament, whether as an integral part or as a first step, if subsequent disillusionment is to be avoided.

"(b) *Atomic Production for Military Purposes.* Stopping the production of nuclear weapons is more fundamental than stopping nuclear tests. Any agreement to stop tests requires a further commitment to stop production. Measures undertaken to ensure compliance would constitute a major element in a broader system of disarmament.

"(c) *Measures for Disarmament.* Partial disarmament measures must always be seen in relation to comprehensive disarmament. The whole range of the disarmament problem, including provisions for warning against surprise attack, must be dealt with as may be appropriate and practicable: conventional armaments, guided missiles, biological and chemical warfare, as well as nuclear weapons. As progress is made toward disarmament, international forces, and instruments for peaceful settlement, the need to rely on atomic deterrents will be reduced.

"(d) *Cooperation in Atoms for Peace.* Both the hazards of diversion of fissionable material to military purposes and of waste disposal need to be considered in relation to a broader system of atomic control and general disarmament. International safeguards against diversion may indeed grow in importance as the use of fissionable material for military purposes decreases.

"(e) *Peaceful Settlement and Peaceful Change.* Ultimately true peace rests upon the continuing adjustment of conflicting interests and claims. To this end, international instruments must be strengthened and established, and must be related to the requirements of an international security system. But local conflicts may break out with the danger that atomic weapons may be used. Therefore the nations must seek to avert such conflicts by timely negotiation and conciliation. If all these efforts fail, they must strive to deal with conflicts without recourse to atomic weapons.

"II. *Moving Forward*

"It is important to stress all of the objectives in their interrelationship. Yet simultaneous progress towards all

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of them seems improbable, until there is a much greater degree of international confidence. Is it safe to advance towards one or more without the others? Choices will have to be made, and they are hard choices. Any decision involves risk. But to make no decision may be even more dangerous.

"Each proposed partial agreement, such as cessation of testing, needs to be considered on its own merits. But it also should be appraised by the extent to which it advances or retards the attainment of related objectives. Again, each proposal should be judged in terms of its potential contribution to mutual confidence.

"The dangers involved are unprecedented. Technical obstacles to effective inspection and control grow with every delay. Both factors impose a compelling sense of urgency. Yet stubborn moral and political factors require unremitting patience and persistence, because time and effort may bring opportunities not now apparent.

"Easy solutions cannot be expected for the problems which plague man in an atomic age, both because the problems themselves are complex and man himself is sinful. God stands in judgment over all the nations of the world, and it is not for man to presume to identify his cause with the fullness of God's purposes. For it is man's disobedience which is the basic cause of his despair and frustration. Christians, who share with all men in the guilt of the world, have nevertheless a hope which transcends the failures and successes of history, and a faith which overcomes fear.

"If persistent efforts bring no sufficient agreement on any of the interrelated objectives, Christians can oppose counsels of despair and still strive to establish true conditions of peace. Moreover, there is a risk for the sake of peace which Christians, especially in countries projecting tests of nuclear weapons, are justified in advocating, in the hope of breaking through the barriers of distrust. They can urge their governments to declare their resolve to forego tests for a trial period, in the hope that others will do the same, a new confidence be born, and foundations laid for reliable agreements."

World Council's Message

The Central Committee of the World Council issued its own message to the churches on August 6, 1957, accompanying the statement of the Commission of the Churches on International Affairs. A number of paragraphs are here quoted from the Central Committee's document:

"We recognize that the question of stopping the testing of nuclear weapons has to be considered in the wide context which is set out in the C.C.I.A. statement. We agree that it is not possible to deal with one part of the interrelated disarmament problem. . . .

"There are, however, certain moral principles affecting the whole issue of atomic warfare which we desire to emphasize. The Central Committee reaffirms the conviction expressed at its Toronto meeting in 1950 that 'such methods of modern warfare as the use of atomic and bacteriological weapons and obliteration bombing involve force and destruction of life on so terrible a scale as to imperil the very basis on which law and civilization can exist.' The condemnation of such methods finds broad support in the fact that total war in the sense of warfare without any limitation in the methods employed is universally in conflict with the conscience of mankind. We also believe that the use of such methods of warfare inevitably involves spiritual degradation for any nation that uses them.

"We are bound to ask ourselves whether any nation is justified in continuing the testing of nuclear weapons while the magnitude of the dangers is so little known and while effective means of protection against these dangers are lacking. We must ask ourselves further whether any nation is justified in deciding on its own responsibility to conduct such tests, when the people of other nations in all parts of the world who have not agreed may have to bear the consequences. Therefore, we call upon each nation conducting tests to give full recognition to this moral responsibility as well as to considerations of national defense and international security.

"Nothing less than the abolition of war itself should be the goal of the nations and their leaders and of all citizens. The attainment of this goal constitutes a solemn challenge to our particular generation. We welcome and support every honest effort now being made to limit and control armaments of all kinds and to establish conditions for a secure peace. We repeat the Evanston appeal for prohibition of all weapons of mass destruction, including atomic and hydrogen bombs, with provision for international inspection and control.

"We know that a comprehensive program for disarmament must proceed by stages, and we realize how much depends upon the deepening of confidence between the nations. But we urge that as a first step governments conducting tests should forego them, at least for a trial period, either together, or individually in the hope that the others will do the same, a new confidence be born, and foundations be laid for reliable agreements. . . .

"No Short Cut to Nuclear Disarmament"

Proposals for cessation of bomb tests by international agreement, or for their limitation, or for their registration, come "at an apt moment," and "point an apt moral, which is that there is no short cut to nuclear disarmament," states *The Economist,* London, May 11, 1957. Mere emotion is a "treacherous counsellor . . . , however natural." The current outcry "demonstrates the need for some attempt to disentangle the issues, and within the limits of incomplete knowledge, the facts."

"The use of hydrogen bombs by both sides in another conflict would certainly be suicidal; but, because of this, the possession of hydrogen bombs by both sides may be a means to prevent another world war. This is the balance of terror to which Sir Winston Churchill has attached his eloquent hope."

Those who would ban the bombs propose varied means from varied motives. If an international agreement could be secured, with international inspection and control, "there is no known means . . . of making sure that no stocks of bombs exist." Also, if a full agreement could be secured respecting the bombs, "it would leave the Russians and their allies with strategic superiority, both in conventional weapons and in manpower."

Thus the proposed ban on bombs is inextricably a part of "the plodding search for disarmament," which falls within "the framework of painstaking diplomacy."

"The truth is that, though the universal horror of the bomb is a powerful force, the demon cannot be exorcised simply by calling the bans. The way to peace is still by the long hard road of defense and diplomacy. Many of the implications of what is being done are alarmingly unknown, and this time the penalty for failure may well be universal ruin, but there is still no short cut to the safety we all crave."

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